Soft tissue stability and volumetric changes after 5 years in pontic sites with or without soft tissue grafting: a retrospective cohort study

Sanz-Martín, Ignacio ; Sailer, Irena ; Hämmerle, Christoph H F ; Thoma, Daniel S

Abstract: UNLABELLED To evaluate volumetric changes (VC) of pontic sites with or without soft tissue grafting over 5 years. MATERIAL AND METHODS Twelve patients participating in a prospective clinical trial evaluating fixed dental prostheses (FDPs) were selected on the basis of having received a subepithelial connective tissue graft for soft volume augmentation in pontic sites (augmentation group [AG]). An additional 12 patients, belonging to the same study, that had not received soft tissue grafting were used as controls (control group [CG]). Casts made from dental impressions taken at prosthesis delivery (baseline [BL]) and at 5 years (5-FU) were digitized, and linear and volumetric measurements performed to assess the soft tissue pontic height (PH), abutment height (AH), (VC) and changes in tissue thickness (TT) on the buccal side of the pontics. RESULTS There were no significant differences at BL between the two groups for linear measurements ($P > 0.05$). The changes in soft tissue pontic height (PHC) amounted to a loss in the height of 0.34 mm (SD = 0.5) and 0.35 mm (0.2) for AG and CG, respectively. The mean VC amounted to a loss of 5.31 mm(3) (±1.1) (AG) and 4.32 mm(3) (±1.7) (CG). None of the changes between BL and 5-FU in volumetric and linear measurements, including TT and mean mesial and distal abutment height changes (mAHC and dAHC), reached statistically significant differences between AG and CG ($P > 0.05$). However the changes in linear measurements from BL to 5-FU were significant in all parameters for both groups ($P < 0.01$). CONCLUSION At an observational period of 5 years, pontic sites with or without grafting under FDPs demonstrated similar dimensional stability. CLINICAL RELEVANCE Pontic sites with or without grafting are volumetrically stable over 5 years.

DOI: https://doi.org/10.1111/clr.12743

Soft tissue stability and volumetric changes after 5 years in pontic sites with or without soft grafting. A retrospective cohort study.

Sanz Martin I[1], Sailer I[2], Hämmerle CHF[3], Thoma DS [3]

[1] Section of Periodontology, Faculty of Odontology, University Complutense of Madrid, Madrid, Spain.

[2] Division for Fixed Prosthodontics and Biomaterials, Center of Dental Medicine, University of Geneva, Geneva, Switzerland.

[3] Clinic of Fixed and Removable Prosthodontics and Dental Material Science, Center for Dental Medicine, University of Zurich, Zurich, Switzerland.

Key words: "soft tissue", "humans", "crown", "fixed, partial, denture", "pontic" "volumetric analysis" "connective tissue"

Running title: 5-year changes at pontic sites with or without grafting.

Address for correspondence:

PD Dr. Daniel S. Thoma

Clinic of Fixed and Removable Prosthodontics and Dental Material Science

Center of Dental Medicine, University of Zurich

Plattenstrasse 11

CH-8032 Zurich, Switzerland

Phone: +41 1 634 32 52

Fax: +41 1 634 43 05

e-mail: daniel.thoma@zzm.uzh.ch

ABSTRACT

Objective: to evaluate volumetric changes of pontic sites with or without soft tissue grafting over 5 years.

Material and Methods: Twelve patients participating in a prospective clinical trial evaluating fixed dental prostheses (FDPs) were selected on the basis of having received a subepithelial connective tissue grafting for soft volume augmentation in pontic sites (augmentation group = AG). An additional 12 patients, belonging to the same study, that had not received soft tissue grafting, were used as controls (CG). Casts made from dental impressions taken at prosthesis delivery (baseline=BL) and at 5 years (5-FU) were digitized and linear and volumetric measurements performed to assess the soft tissue pontic height (PH), abutment height (AH), volumetric changes (VC) and changes in tissue thickness (TT) on the buccal side of the pontics.

Results: There were no significant differences at baseline between the two groups for linear measurements ($p>0.05$). The changes in soft tissue pontic height (PHC) amounted to a loss in height of 0.34mm (SD=0.5) and 0.35mm (0.2) for AG and CG respectively. The mean VC amounted to a loss of 5.31 mm^3 (±1.1) (AG) and 4.32mm^3 (±1.7) (CG). None of the changes between BL and 5-FU in volumetric and linear measurements, including TT and mean mesial and distal abutment height changes (mAHC and dAHC) reached statistically significant differences between AG and CG ($p>0.05$). However the changes in linear measurements from baseline to 5-FU were significant in all parameters for both groups ($p<0.01$).

Conclusion: At an observational period of 5 years, pontic sites with or without grafting under FDPs demonstrated similar dimensional stability.

Clinical relevance: pontic sites with or without grafting are volumetrically stable over 5 years.

INTRODUCTION:

Plastic periodontal procedures to augment soft tissue volume at pontic sites are well described in the dental literature (Esposito et al. 2012; Thoma et al. 2014). The techniques utilized to augment the tissue volume vary and include the use of biomaterials such as hydroxyapatite (Allen et al. 1985), free gingival grafts (Studer et al. 2000), connective tissue grafts (Akcali et al. 2015) and soft tissue allografts (Batista et al. 2001).

A recently published systematic review concluded that due to the heterogeneity of the publications evaluated no meta-analysis could be performed. (Thoma et al. 2014) The superiority of any of the aforementioned techniques is therefore unknown and no long-term observational data is available. However, in all the publications evaluating soft tissue augmentation at localized alveolar ridge defects, the subepithelial connective tissue graft was the treatment of choice as a control group (gold standard).

Although there is no scientific evidence to indicate that the maintenance of soft tissue volume at pontic sites will improve the long-term success and survival rates of FDPs (Pjetursson et al. 2007), volume changes at the buccal aspect may have a negative impact on the esthetic appearance of FDPs. Moreover, the loss of contact between the pontic and the edentulous ridge may facilitate food impaction and reduce patient comfort (Dina et al. 2013).

The assessment of the soft tissue volume stability was in the past a challenging task due to the paucity of tools suitable to evaluate soft tissue changes. Recently, digital optical scanning and assessment methods have been applied with the aim of

measuring volume changes of oral tissues over time (Thoma et al. 2010). Calibration studies demonstrated precision and reliability of these methods to assess soft tissue volume changes in a non-invasive way (Windisch et al. 2007). This method has successfully been used to assess the volume changes in the alveolar process in conjunction with soft and hard tissue augmentation in preclinical and clinical studies (Fickl et al. 2009; Schneider et al. 2011).

The aim of the present study was therefore to assess the long-term soft tissue changes between baseline (BL; prosthesis delivery) and the 5-year follow-up (5-FU) comparing pontic sites with and without previous soft tissue grafting in patients receiving tooth-borne fixed dental prostheses (FDPs).

MATERIALS AND METHODS

Study design

The study was designed as a controlled clinical study. Ethic approval was obtained by the regional authorities (StV Nr. 01 / 03). Twelve patients that participated in a randomized controlled clinical trial evaluating zirconia frameworks for posterior 3-unit FDPs were selected on the basis of having received connective tissue grafting for soft tissue volume augmentation at the pontic sites (augmentation group=AG). Twelve additional patients that participated in the same clinical trial and had not received any soft tissue augmentation procedures were randomly selected to serve as controls (control group=CG).

Patients and prosthodontic procedures

Only patients in good general health were included in this study. Furthermore, the included patients had to be periodontally healthy with no clear sign of bruxism.

The pre-prosthetic as well as the prosthetic treatment for both types of FDPs were performed according to standard techniques applied at the Clinic of Fixed and Removable Prosthodontics and Dental Material Science, University of Zurich. The abutment teeth were prepared according to computer-assisted manufacturing (CAM) recommendations.

Surgical procedures

Following the insertion of a provisional prosthesis and a period of adaptation time, patients were recalled for the surgical augmentation procedure (Fig. 1a). In brief, crestal incisions were placed followed by partial thickness elevation of the vestibular flap (Fig. 1b). In addition, periosteal releasing incisions were performed to assure tension-free closure. The pontic site was then measured and a subepithelial connective tissue graft was harvested from the palate according to the pontic

dimensions by means of a single incision technique (Hurzeler and Weng 1999). Primary wound closure was achieved in the palate with the use of cross mattress sutures. At the recipient site, the SCTG was fixed in the buccal aspect and closure was achieved by horizontal mattress and single interrupted sutures (Fig. 1c). The pontic area of the provisional restorations was reduced to avoid compression of the tissues. Patients were recalled one week after the surgical appointment for suture removal. Tissue management was performed by gradually increasing the contact of the pontic areas with the soft tissues and began at 6-10 weeks after soft tissue grafting surgery (Fig. 1d,e). Final full arch impressions were taken after tissue sculpturing was finalized and tissues were deemed stable (Fig. 1f). One experienced technician manufactured both ceramic and metal frameworks. Reconstructions were cemented with a resin cement (Panavia 21 TC, Kuraray) (Fig. 1g)

Further details regarding the prosthodontic procedures can be found in earlier publications reporting on the 5-year follow up clinical outcomes (Sailer et al. 2006; Sailer et al. 2007; Sailer et al. 2009)

Model Fabrication

Alginate impressions were taken at prosthesis delivery (BL) and at the five-year follow-up (5-FU). Dental stone casts were fabricated immediately after the impressions were obtained. A total of 24 pairs of models were obtained. Models were strictly evaluated for the presence of irregularities such as porous areas, undefined gingival margins, broken cusps or an undefined vestibule.

Following this examination, 21 pairs of casts (BL and 5-FU) were deemed appropriate for volumetric analysis (10 AG and 11 CG).

STL Image acquisition, matching of data and volume analysis

Cast model were optically scanned with a desktop 3D scanner (Imetric 3D.Courgenay,Switzerland). BL and 5-FU STL files of the models of the 21 patients were uploaded to an image analysis software (SMOP, Swissmeda AG, Zürich, Switzerland). In order to match the STL files, three clear and visible common references were selected in both the BL and 5-FU casts. After the selection of these references, the software automatically aligned these points together. This process was repeated until image superimposition was considered adequate by having the known unchanged areas superimposed (Fig. 3). A final adjustment was done using a "*fine fit"* command by which the software looks for the best fit between the two images using a series of mathematical algorithms.

Image analysis:

If the pontic site had two pontic teeth, both pontic areas were evaluated separately and the mean values were utilized. The following measurements were performed:

i) Linear measurements: A longitudinal slice that divided the pontic and abutment crowns mesio-distally into two equal parts was selected. A line coinciding with the axis of the crown was then drawn in the transversal images of the cuts. The apico-coronal height of the mesial and distal abutment crown (mAH and dAH) and the soft tissue pontic height (PH) at BL and at 5-FU were assessed by measuring the distance between two lines perpendicular to the axis of the tooth coinciding with the most prominent cusp and the gingival/pontic margin. In order to evaluate the changes in the soft tissue thickness (cTT), the distance from the two scanned surfaces was assessed at 1,3 and 5mm below the mucosal margin at BL and at 5-FU (Fig 4).

ii) Volumetric measurements: The selected area used to evaluate the volume changes followed the mucosal margin of the pontic restoration, it reached the mesial and distal line angles and extended apically 5-6mm (Fig 5). The software then calculated the volume change (VC) measured in $mm^{3,}$ which corresponded to the

volume enclosed between the two surfaces involved within the designed area. The software calculated as well the mean distance in mm between the two surfaces (MD).

Statistical analysis

Descriptive statistics (means and standard deviations) of continuous variables and relative frequencies of discrete variables were computed for each system separately using a statistical software program (SPSS Version 20.0, IBM Corporation. New York, USA). The Mann-Whitney test was used to disclose differences for continuous variables with respect to a factor with two levels. In order to express the influence of time the differences between the 5-year values and the baseline values were computed and analyzed with a Mann-Whitney test. The results of statistical tests with p-values smaller than 0.05 were interpreted as statistically significant.

RESULTS

Twenty-one patients (10 female and 11 male) contributing with one FDP each were examined after a mean follow-up of 59 months (SD=2.8 months). The mean age at the 5-year follow-up in the AG was 56.1±12.2 years and 54.8±10.7 for CG.

Patients in the AG healed uneventfully after the grating procedure and were restored with a total of 7 three-unit FDPs and 3 four-unit FDPs, whereas the CG was restored with 11 three-unit FDPs.

Baseline (BL) linear measurements:

In the AG, the mean soft tissue pontic height at baseline (PH) was 7.92mm (±0.9), whereas in the CG this corresponded to 7.89mm (±1.2).

The mean mAH was 7.54 mm (±1.4) and the mean dAH was 6.12mm (±0.9) for AG, whereas in CG these values amounted to 8.07mm (±1.0) for mAH and 6.61mm (±0.7) for dAH.

There were no statistically significant differences between the two groups at BL for any of the parameters ($p>0.05$) *(Table 1)*

Linear and volumetric changes between BL and 5-FU

The changes in linear measurements were calculated subtracting the 5-FU from BL values. The changes in pontic height (PHC) amounted to a loss in height of 0.34mm(±0.5) and 0.35mm(±0.2) for the AG and CG respectively. In the AG, the mean abutment height changes (mAHC and dAHC) amounted to 0.36mm (±0.3) and 0.37mm (±0.3), whereas the CG exhibited a change of 0.15mm (±0.2) and 0.22mm (±0.3) for the respective values. The mean VC amounted to a loss of 5.31 mm^3 (±1.1) (AG) and of 4.32mm^3 (±1.7) (CG). The MD between the two surfaces within the designed area was 0.19mm (±0.5) for the AG and 0.16mm (±0.3) for the CG.

With regards to the changes in tissue thickness, the AG presented a change of 0.31mm (±0.1) at 1mm, 0.37mm (±0.2) at 3mm and 0.42mm (±0.2) at 5mm below the mucosal margin. The respective values for the CG were 0.35mm (±0.2), 0.36mm (±0.2) and 0.41mm (±0.2) at the three levels.

No statistically significant differences were found between the two groups for any of the above-mentioned parameters ($p>0.05$). However, there was a tendency indicating less tissue contraction for the control group in the mAHC ($p=0.08$). *(Table 2)*

Although the differences were not significant between groups, the changes between BL and 5-FU for linear measurements were analyzed separately for each system to investigate the influence of time in these variables. The changes between BL and 5-FU were significant for all linear measurements in both groups ($p<0.01$).

DISCUSSION

In the present investigation minor changes were observed in both groups in terms of soft tissue changes between the insertion of the final reconstruction and the five-year follow-up evaluation. Despite of these changes being considered as minor clinically, the differences between BL and 5-FU still reached statistical significance. With regards to tissue thickness, soft tissue pontic height, abutment height and facial pontic volume, no significant differences were found between AG and CG. Both groups seemed to demonstrate equal dimensional stability of the buccal tissues over 5 years.

Soft tissue grafting procedures have become routine interventions in mucogingival surgery to improve the resemblance between the reconstructed parts and the natural dentition (Cairo et al. 2008). Despite of this, little is known about the long-term stability of sites augmented following soft tissue volume grafting procedures (Thoma et al. 2014).

The pontic site appears to be the ideal model to evaluate the stability of soft tissue grafts over time since it rules out other aspects that may have an influence on the preservation of tissue such as peri-implant bone levels, soft tissue recession and gingival inflammation.

The findings of this study relate to those published earlier by Allen et al. (Allen et al. 1985). In that study, soft tissue changes were evaluated 36 months after grafting with connective tissue grafts and hydroxyapatite. A visual inspection of the 14 sites grafted with fibrous connective tissue reported high stability of the areas, however no standardized clinical measurements were performed.

A recently published randomized controlled clinical trial compared pontic sites grafted with either SCTGs or palatal vascularized interpositional periosteal-connective tissue

graft (VIPCG) (Akcali et al. 2015). The outcomes demonstrated a contour change in labial distance between baseline and the 6-month follow-up of 1.2mm for VIPCG sites and 0.6 mm for SCTG sites. In addition, a loss of the initial volume (gained at baseline) was reported, amounting to 47% at 6 months for SCTG sites and to 6.4% for VIPCG sites.

The findings of the latter study are difficult to compare with the findings obtained in the present study. The focus of the present investigation was the long-term stability of the augmented sites starting at the day of cementation (BL). The initial volume gain and a potential volume loss between the grafting and cementation of the reconstruction were therefore not recorded.

The reported volume loss reached 5.31 mm^3 for AG and 4.32 mm^3 for CG. This was considered as a minor change. However, bearing in mind that an initial value for the volume gain is lacking, this parameter appears to be difficult to judge. In a pilot study, 5 patients were evaluated contributing with 5 edentulous sites and followed for 5 months after soft tissue augmentation (Gonzalez-Martin et al. 2014). In that study, the volume gain after connective tissue grafting in pontic sites was analyzed utilizing an image analysis software for STL model superimposition. Five months post surgery, a mean soft tissue volume increase of 35 mm^3 (ranging from 12.80 mm^3 to 52.59 mm^3) was reported. Other methods such as the Moiré system have been utilized to assess volume augmentation at pontic sites (Studer et al. 2000). Pontic sites augmented with SCTG or free gingival grafts were evaluated for volume changes. The twelve patients that received SCTG reported a gain in volume of 159 mm^3 at the 3.5 month follow-up.

Regarding the linear measurements in the present study, AG showed a tendency for greater loss of mucosal height in the mesial abutments. The values for the distal abutments were also higher for the AG. Although mucosal recession may be an

expected phenomenon in patients with FDPs, the values in this study were all bellow 0.5mm, which may not be of clinical relevance. Other linear parameters that represent a more homogeneous variable of the area evaluated such as MD or PH showed high similarities between both groups.

Unfortunately, the present study cannot be compared with other investigations that have analyzed volume changes at implant sites over time (Sanz Martin et al. 2015). This is mainly due to the heterogeneity found in the study models since the buccal peri-implant tissue may be influenced by parameters such us the peri-implant marginal bone levels or prosthesis design.

It must be taken into consideration that the data presented were obtained in a retrospective manner and some important variables such as graft dimensions could not be assessed. Moreover, the impressions were made of alginate, which may introduce accuracy issues. In fact, one pair of casts was excluded due to model artifacts that did not allow for STL matching and two pairs were excluded due to minor tooth drifting that made accurate matching more challenging.

However, the data introduced were obtained by the use of a reliable method to superimpose digital STL files of the models obtained at BL and 5FU to compare tissue height changes in the pontic and abutments of three- and four-unit FDP's. The manufacturer of the optical scanner reports accuracy values to be <20μm over complete arch scanners. The accuracy of the optical method evaluated has been tested and shown to be very high with differences between test and control measurements never exceeding 1.5%. The reproducibility of the these values has been shown to have very low coefficients of variation ranging from 0.05 to 0.5% indicating excellent reproducibility (Windisch et al. 2007)

Conclusions

From the data analyzed it can be concluded that minor changes occurred in the pontic areas grafted with a SCTG from the day of cementation to the 5-year follow-up visit. No significant differences were found with the control (non-grafted) sites in terms of linear and volumetric measurements.

CONFLICTS OF INTERESTS and ACKNOWLEDGEMENTS

This study was funded by the Clinic of Fixed and Removable Prosthodontics and Dental Material Science, School for Dental Medicine, University of Zurich, Zurich, Switzerland. The authors report no conflict of interest for this study.

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Figure Legends

Figure 1a: Pre-operative occlusal view before soft tissue grafting .

Figure 1b: Crestal incision and split thickness preparation of the buccal flap.

Figure 1c: Connective tissue graft is fixed in the buccal aspect and single interrupted sutures are used to close the site.

Figure 1d: Three months post connective tissue grafting.

Figure 1e: Clinical image after connective tissue grafting and before tissue conditioning.

Figure 1f: Clinical image after tissue conditioning was concluded with a provisional restoration.

Figure 1g: Delivery of the final restoration (Baseline, augmentation group)

Figure 1h: Five year follow up (augmentation group)

Figure 2a: Control site at restoration delivery (Baseline, control group)

Figure 2b: Five year follow up (control group)

Figure 3: STL image superimposition of baseline and five year follow up models and volumetric analysis. The colored area represents the area analyzed.

Figure 4: Outline of baseline and five-year follow-up models and linear measurements performed in central section in a control case. Baseline model (yellow) and five year follow-up (green). PH=Pontic height. T1mm= thickness at 1mm below the gingival margin. T3mm= thickness at 3mm below the gingival margin . T5mm= thickness at 5mm below the gingival margin.

Figure 5: Volume loss visible on buccal side of FDP in pontic area after 5 years of connective tissue grafting.

Table 1. Linear measurements at baseline. SD=standard deviation.

Table 2. Changes between baseline and five year follow up in linear measurements

and volumetric measurements. SD=standard deviation.

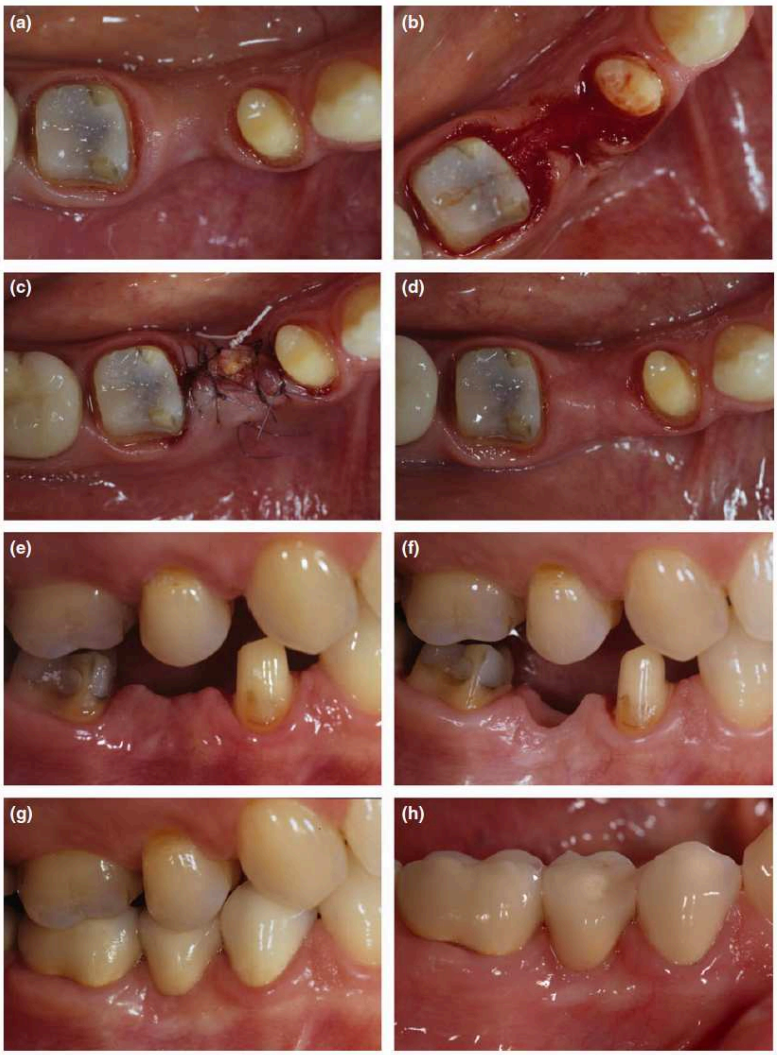


Figure 1

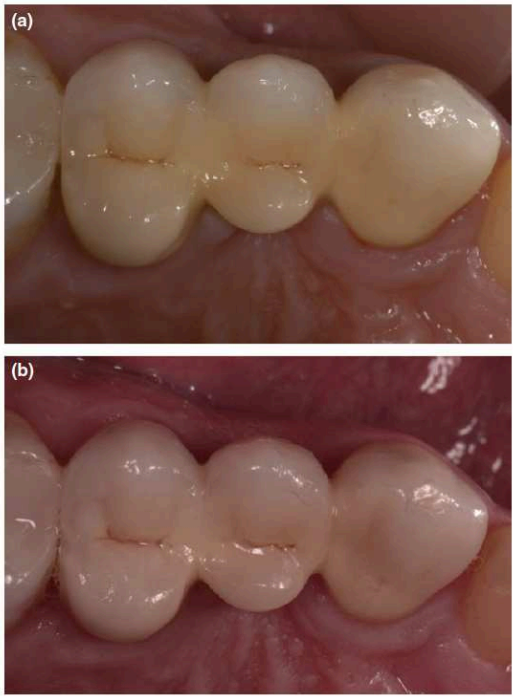
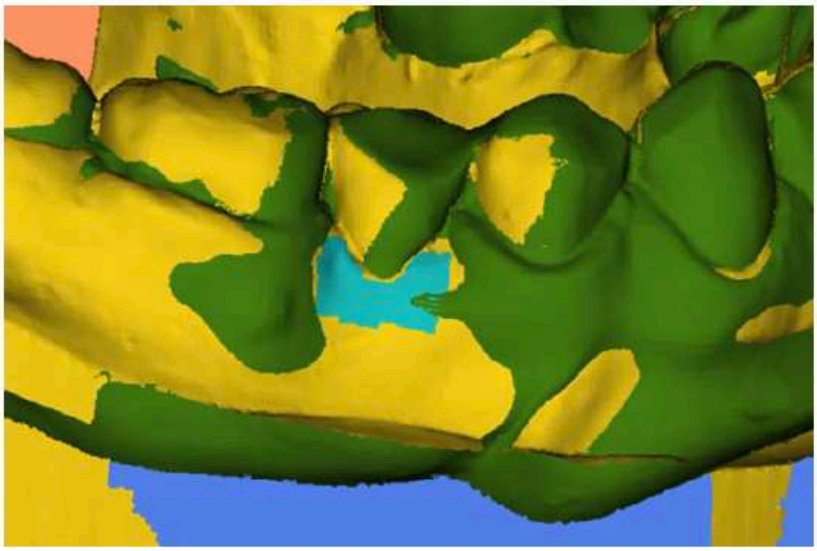


Figure 2



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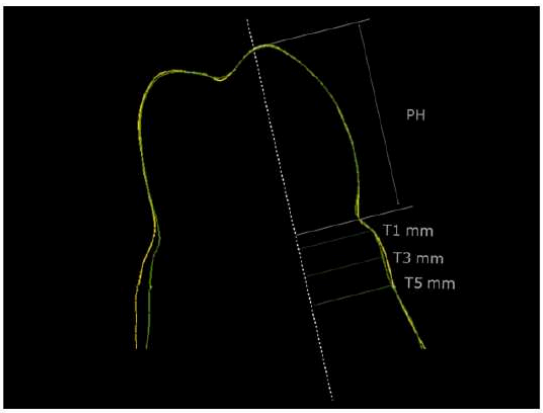

Figure 4

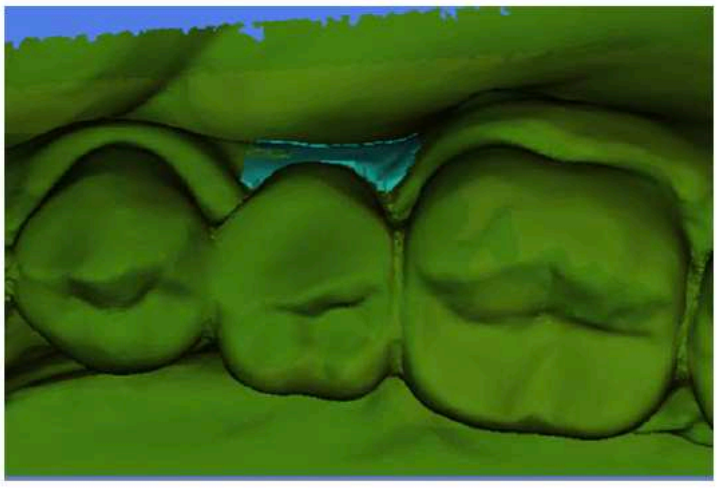

Figure 5

Table 1.

Variables in mm **Mean(SD)/Median**	**SCTG**	**CONTROL**	**Significance**
Pontic Height (PH)	7.92(0.9)/7.77	7.89(1.2)/7.99	0.95
Mesial Abutment Height (mAH)	7.54(1.4)/7.11	8.07(1.0)/7.82	0.34
Distal Abutment Height (dAH)	6.12(0.9)/5.89	6.61(0.7)/6.40	0.17

Table 2.

Variables in mm **(Mean(SD)/Median)**	**SCTG**	**CONTROL**	**Significance**
Pontic Height Changes (PHC)	0.34(0.5)/0.16	0.35(0.2)/0.34	0.55
Mesial Abutment Height Changes (mAHC)	0.36(0.3)/0.24	0.15(0.2)/0.12	0.08
Distal Abutment Height Changes (dAHC)	0.37(0.3)/0.27	0.22(0.3)/0.07	0.22
Volume Changes (VC) in mm^3	5.31(1.1)/5.46	4.32(1.7)/4.30	0.13
Mean Distance (MD)	0.19(0.5)/0.19	0.16(0.3)/0.10	0.42
1mm Changes	0.31(0.1)/0.33	0.35(0.2)/0.42	0.38
3mm Changes	0.37(0.2)/0.38	0.36(0.2)/0.38	0.19
5mm Changes	0.42(0.25)/0.33	0.41(0.2)/0.37	0.55